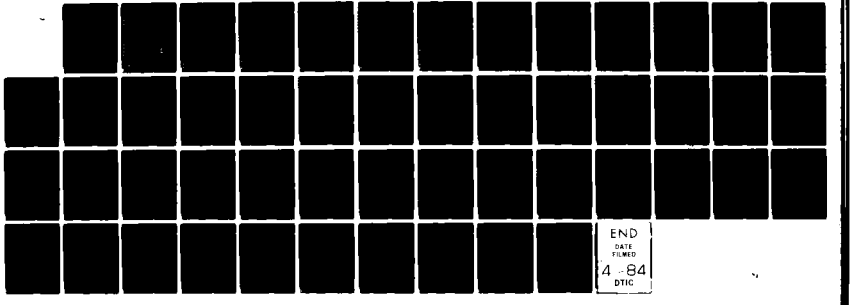
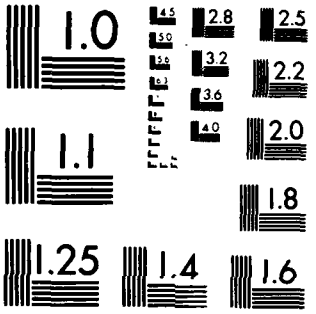
AD-A138 983 EVALUATION OF THE TRI-SERVICE LABORATORY SYSTEM VOLUME 1/1
1 OVERVIEW AND EXECUTIVE SUMMARY(U) LITTLE (ARTHUR D)
INC CAMBRIDGE MA 20 JUN 83 MDA903-81-C-0209

UNCLASSIFIED F/G 9/2 NL



END
DATE FILMED
4-84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(3)

0209-2-LAB-1-FINAL-VOL. I

AD A138983

EVALUATION OF THE TRI-SERVICE LABORATORY SYSTEM

VOLUME I
OVERVIEW AND EXECUTIVE SUMMARY

ARTHUR D. LITTLE, INC
Acorn Park
Cambridge, Massachusetts 02140

June 20, 1983

Final Report for Period 2/17/82-6/20/83

Prepared for

TRIMIS Program Office
5401 Westbard Avenue
Bethesda, Maryland 20816

DTIC
ELECTE
MAR 1 4 1984
S
A

DTIC FILE COPY

This document has been approved for public release and sale; its distribution is unlimited.

84 03 13 165

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: 0209-2-LAB-1-FINAL-VOL. I	2. GOVT ACCESSION NO: AD-A138 983
3. RECIPIENT'S CATALOG NUMBER:	
4. TITLE (and Subtitle): Evaluation of the Tri-Service Laboratory System, Vol. I, Overview and Executive Summary	5. TYPE OF REPORT & PERIOD COVERED: 2/17/82-6/20/83
	6. PERFORMING ORG. REPORT NUMBER: 86290
7. AUTHOR(s): Arthur D. Little, Inc.	8. CONTRACT OR GRANT NUMBER(s): MDA-903-81-C-0209
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Arthur D. Little, Inc. Acorn Park Cambridge, MA 02140	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: TRIMIS Program Office 5401 Westbard Avenue Bethesda, Maryland 20816	12. REPORT DATE: 6/20/83
	13. NUMBER OF PAGES: 90
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS (of this report)
	15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release, Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Clinical Laboratory, Automation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Overview and Summary--results of the evaluation of the Tri-Service Laboraotry (TRILAB) System at Naval Regional Medical Center, Oakland.

DTIC COPY INSPECTED

A-1

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

EVALUATION OF THE TRILAB SYSTEM: EXECUTIVE SUMMARY

A. INTRODUCTION

The military services, with the coordination of The Tri-Service Medical Information (TRIMIS) Program Office (TPO), have installed computerized medical laboratory systems (TRILAB) in three military hospitals:

- Naval Regional Medical Center (NRMC), Oakland;
- Dwight D. Eisenhower Army Medical Center (DDEAMC), Fort Gordon, Georgia; and
- Wright Patterson Medical Center and Regional Hospital (Wright Patterson), Dayton, Ohio.

The TRILAB system is designed to support the following laboratory activities: patient files, test order entry, specimen accessioning and control, work document preparation, quality control, test result entry, inquiry and test retrieval, test result reporting at wards and clinics, and management reporting. The system is designed to have automated, high-volume test instruments on-line, with the goal of reducing clerical work of laboratory technicians and transcription errors, and to monitor quality control samples in order to check for correct calibration of instruments and proper handling of specimens within the laboratory. The system produces interim test result reports, daily cumulative reports, and cumulative summary discharge reports. In addition, the system produces management information, such as laboratory workload summary reports. The system supports terminals outside the laboratory, such as in wards, clinics, and satellite facilities, for transmission of results and for inquiries as to test status.

Arthur D. Little, under contract to the TPO, conducted an evaluation of the TRILAB system. The evaluation was based primarily on a comparison of information and data on operations collected at NRMC Oakland, which was chosen as the primary evaluation site for the system. Baseline data were collected during the fall of 1980, prior to implementation of the TRILAB system which occurred early in 1982.

The post-implementation survey was carried out in October 1982. In addition to the comprehensive evaluation for NRMC Oakland, pre- and post-implementation surveys were carried out at Wright Patterson, and interviews and implementation monitoring were performed at Eisenhower.

On July 15, 1977 the TRIMIS Medical Review Group (MRG) developed seven project objectives for the Tri-Service Laboratory System:

- To make information available to physicians with increased efficiency and accuracy;
- To present the data in a convenient and meaningful manner with sufficient variety in report formats to meet the needs of all users;
- To be able to handle increased demands for laboratory tests without significant increases in staff;
- To provide accountability of laboratory requests and to monitor generation of test results to include providing notices of abnormal values or improper quality control results as soon as they are available;
- To gather, as a result of normal procedures, workload and managerial data, and to present this as required in order to assist in decision-making in the laboratory;
- To reduce the clerical work required of qualified technicians in the laboratory;
- To improve result accuracy by eliminating transcription, calculation, and specimen identification error.

The next sections summarize the specific findings and relate them to these project objectives.

B. FINDINGS

1. Time devoted to information handling. At Oakland, time devoted to information handling activities in the post-implementation period was approximately 2.6% lower than in the baseline period. Based on current staffing, this was equivalent to a net reduction of 34 hours per week (day shift, Monday through Friday) devoted to information handling activities in the Chemistry, Hematology and Microbiology Sections. There were reductions in time devoted to transcription and recording of test results, compilation of workload statistics, and for quality control reporting.

2. Turnaround time. For STAT/urgent tests, process times--times between receipt of requisition and transmission of test result to provider locations (via telephone in the baseline period and via terminal in the post-implementation period)--were either unchanged (Chemistry) or reduced (Hematology).

For routine tests, results were available to provider locations (via terminal) sooner in the post-implementation period than in the baseline period for Chemistry and Hematology, and in about the same time period or sooner for Microbiology. Hard-copy daily reports from the system were generally available to providers later than the completed results requisition slips were in the baseline period. The hard-copy interim reports (for the surgical floors) were available sooner in the post-implementation period for hematology tests and in approximately the same time for chemistry and microbiology tests.

3. Number of telephone calls. Volume of telephone calls to the laboratory to inquire about test status or test results was reduced considerably at all three sites after implementation of the TRILAB system. The volume of telephone calls in the post-implementation period was almost half that in the baseline study period.

4. Staff perception of laboratory services. In addition to the significant reduction in telephone calls, laboratory staff indicated that time spent on manual record keeping was reduced as a result of implementation of the TRILAB system. Transcription discrepancies and repeating of tests due to inaccurate results were judged to occur with similar, or slightly less frequency, as a result of implementation of TRILAB.

Providers showed positive changes in attitudes toward laboratory services after implementation of the TRILAB system. Problem occurrences were considered to be less frequent after implementation of TRILAB. Providers felt that tests repeated due to delays, volume of telephone calls to inquire about test status and results, tests repeated due to lost results, and tests repeated due to filing delays or due to inaccurate results had all been reduced as a result of the TRILAB installation.

Nursing staff at all three sites estimated that there was considerable reduction in staff time associated with telephoning the laboratory to receive test results and to inquire about late or missing results. Time spent in filing test results and in chart review was reduced due to having cumulative reports available. It was estimated by nursing staff at all three sites that savings amounted to approximately four hours per day per inpatient unit or clinic which had terminals. These savings in staff time, which were made available for other activities and direct patient care, amounted to 75 nursing staff hours per day at NRMC Oakland, 49 hours per day at Wright Patterson, and 26 hours per day at Eisenhower.

In addition to the quantifiable benefits described above, staff reported that morale had improved considerably as a result of the reduction in telephone calls between patient care units and the laboratory, because of the ability to look up test status via the computer terminal. Also, it was felt that patient care had improved as a result of highlighting abnormal results on the reports, and improved ability to obtain results both on current tests and on tests carried out previously.

A further indirect measure of approval of the system was the expressed desire of the staff in those inpatient units and outpatient clinics which did not have terminals for a terminal in their own location.

C. COMPARISON OF RESULTS WITH PROJECT OBJECTIVES

It is concluded that the original project goals have been met by the TRILAB system. The system is very effective in making information available to providers with increased efficiency and accuracy, in presenting test result data in useful and meaningful format, in highlighting abnormal values and monitoring quality control results, and in automatically capturing workload and managerial data. The objectives of enabling the laboratory to handle increased demands for testing and for reducing the clerical work required by laboratory technicians were also met, but more modestly.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

The Tri-Service Medical Information System (TRIMIS) Program Office (TPO) has installed computerized clinical laboratory systems (TRILAB) in three military hospitals:

- Naval Regional Medical Center (NRMC), Oakland;
- Dwight D. Eisenhower Army Medical Center (DDEAMC), Fort Gordon, Georgia;
- Wright Patterson Medical Center and Regional Hospital (Wright Patterson), Dayton Ohio.

The experience with these installations is being evaluated to provide information for use in decision making about the future use of automation in clinical laboratories in other military health care facilities.

The first installation was scheduled for NRMC Oakland, which was chosen as the primary evaluation site for the TRILAB system. The evaluation plan for the TRILAB system was developed by Analytic Services, Inc. (ANSER)[1] who also collected the baseline data at Oakland during an eight-week period (September 29, 1980-November 29, 1980). The implementation of the TRILAB system was initiated in early 1982. The post-implementation survey was carried out in October 1982 by Arthur D. Little, Inc.

In addition to the comprehensive evaluation plan for NRMC Oakland, "mini-evaluations" were subsequently planned for the other two sites (Wright Patterson and Eisenhower). Baseline data, using self-administered questionnaires, were collected by Arthur D. Little, Inc. at these two sites in the fall of 1981. A post-implementation survey was carried out at Wright Patterson in the fall of 1982. The system at Eisenhower, the last of the three facilities to implement TRILAB, had not reached stability and complete implementation at the time of preparation of this report. Based on the findings of implementation monitoring, it is anticipated that the results from Eisenhower would be consistent with the evaluation conclusions based on the other two sites.. Results of the implementation monitoring survey at Eisenhower are included in this report.

An assessment of the baseline data has been reported previously in a six-volume baseline report.[2] This report, Volume I of a four-volume report, presents an overview and executive summary of the evaluation of the TRILAB system. Volume II presents the evaluation for NRMC Oakland and Volume III, the survey results and evaluation for Wright Patterson. Volume IV contains supporting appendices for Volumes II and III.

The next chapter presents a brief description of the TRILAB system and an overview of the TRILAB system objectives and evaluation approach. Chapter III summarizes the results of the evaluation at the three sites. Chapter IV summarizes the overall conclusions.

II. DESCRIPTION OF TRILAB SYSTEM AND EVALUATION APPROACH

A. DESCRIPTION OF TRILAB

The TRILAB system is designed to support the following laboratory activities: patient files, test order entry, specimen accessioning and control, work document preparation, quality control, test result entry, inquiry and data retrieval, test result reporting at wards and clinics, and management reporting.

The TRILAB system is designed to have automated, high-volume test instruments on-line, with the goal of significantly reducing clerical work of laboratory technicians and transcription errors. The system is also designed to monitor quality control samples in order to check for correct calibration of instruments and proper handling of the specimens within the laboratory, and to produce interim test results reports, daily cumulative reports, and cumulative summary discharge reports.

In addition, the system produces management information, such as laboratory workload summary reports, which should reduce the effort to prepare management reports and assist in the efficient organization and administration of the laboratory.

The TRILAB system, which uses software developed by Meditech, was obtained from Centennial Systems Corporation through competitive procurement. The system can support terminals outside the laboratory, such as in wards, clinics and satellite facilities, for transmission of results and for inquiry as to test status.

B. DESCRIPTION OF CLINICAL LABORATORY OPERATIONS

Summary statistics for the three evaluation sites are presented in Table 1. During FY 1982, the clinical laboratory at NRMC Oakland performed approximately 2.6 million tests (including quality controls). The clinical laboratory at Wright Patterson is smaller than that at Oakland, with an annual workload of 1.6 million tests per year, while that at Eisenhower is larger, with a volume of 4.6 million tests per year.

TABLE 1

CLINICAL LABORATORY AND HOSPITAL SUMMARY STATISTICS

	NRMC Oakland	Wright Patterson	Eisenhower
Number of Staff	90	42	112
Annual Workload (millions of tests)	2.6	1.6	4.6
Annual Workload (millions of CAP units)	8.9	4.8	15.2
Hospital Admissions	14,600	8,335	13,096
Hospital Patient Days	89,000	104,000	118,110
Hospital Outpatient Visits	376,000	400,000	774,000
Average Inpatient Census	244	285	324

The three sites differed in number and configuration of terminals supported by the TRILAB system (Table 2). Oakland obtained 42 terminals, of which 18 were located in provider areas (inpatient units and outpatient clinics). Wright Patterson received 25 terminals, of which 14 were located in provider areas. Eisenhower received 36 terminals, of which 7 were located in provider areas.

TABLE 2

CRT CONFIGURATION

	NRMC OAKLAND	Wright Patterson	Eisenhower
Laboratory	20	9	29
Inpatient Units	12	6	6
Outpatient Areas	6	8	1
Other	4	2	-
Total	42	25	36

The sites differed also in terms of utilization of the capability of the system to have instruments interfaced on-line. (This permits on-line inputting of test results directly into the computer, rather than manually inputting results through terminals.) Oakland had the SMAC (high-volume chemistry analyzer), Coulter S+ (high volume instrument used in hematology) and Clintech instruments on-line. Wright Patterson had only the Hycel (high-volume chemistry analyzer) on-line. Eisenhower had the SMAC, ABA 200, Clintech, Beckman Astron, and Coulter S+ instruments on-line.

Major differences between the baseline (manual) system and the post-implementation (TRILAB) operations of laboratory services were:

- Providers in locations provided with terminals received results via terminal as soon as they were available, instead of having to wait for telephone calls (in the case of STAT and urgent requests) or the completed test request slip (in the case of routine requests).

- The reports received by providers were cumulative, formatted and on full-size paper, instead of on the original request slips. Medical Records received a single cumulative discharge report for inpatients, rather than a number of slips for each day's tests.
- Within the laboratory, work sheets were prepared by the computer instead of being prepared manually.
- For those instruments which were not on-line to the computer, technicians entered results into the computer memory via terminal, instead of writing the results on the original test request slips. For those instruments which were on-line, the results were automatically entered into the computer memory. Review of test results was expedited in that normal values and outliers were automatically identified, as well as unusual changes from previous patients' test results.
- The computer produced a number of management reports for the laboratory which previously were prepared manually.
- Test status and results could be obtained via inquiry from any terminal connected to the system, instead of by looking up records or telephoning the laboratory.

C. EVALUATION APPROACH

The evaluation plan for the TRILAB system, developed by Analytic Services, Inc. (ANSER), described 36 hypotheses regarding the potential impact of TRILAB on the clinical laboratory and MTF. These were grouped into the following four areas:

- personnel time,
- satisfaction and perception,
- information attributes, and
- cost.

evaluation called for a before-and-after study comparing m oratory operation with operation of the laboratory using the T er system. Two periods of data collection were planned: the d under manual operation before the installation of TRILAB, and the Y Period when TRILAB became operational.

This before-and-after approach was followed in the plans for the three TRILAB evaluations. The elements to be measured, the data collection techniques, and the data obtained at each site during the baseline surveys, are summarized in Exhibit 1.

Four types of data were collected by ANSER during the baseline study at NRMC Oakland:

- Time spent by personnel within the laboratory in information handling activities (using work sampling and timed observations);
- Performance of services (turnaround time for test results in the laboratory process time; transcription discrepancies; number of telephone inquiries about test results; and patient waiting time);
- Staff perceptions of performance of services (staff questionnaire survey); and
- Staff and patient satisfaction (staff and patient questionnaire survey).

AT DDEAMC two types of quantitative information were obtained by Arthur D. Little, Inc.[2] on performance of services:

- turnaround time for laboratory tests, and
- number of inquiries to the laboratory about test results.

The surveys carried out at Eisenhower and Wright Patterson were similar to those carried out at NRMC Oakland, with some modifications made to the survey instruments, e.g., to reflect the fact that Wright Patterson previously had had the Air Force Clinical Automated System (AFCLAS).

The post-implementation evaluation plan was developed with the following considerations:

(1) In order to utilize the baseline data to the maximum extent, and to make the before-and-after comparison as consistent and meaningful as possible, the same evaluative measures, data collection methodologies, and data collection instruments used in the baseline period were used in the post-implementation study to the extent possible. It was necessary, however, to modify

EXHIBIT I

EVALUATION ELEMENTS AND DATA COLLECTION METHODOLOGY FOR THE BASELINE *EVALUATION OF* THE TRI-SERVICE LABORATORY SYSTEMS

Element	Data to be Obtained	Data Collection Methodology	Data Obtained NRMC Oakland	Data Obtained Eisenhower	Data Obtained Wright Patterson
Personnel Time Devoted to Information Handling	Time devoted to information handling activities, e.g., accessioning, logging, result preparation in:				
	Chemistry Hematology Bacteriology	Work sampling	% of time and manhours per week by activity type		
	Blood Bank Reception Area	Timed observations	% of time (minutes) per activity)--day shift, weekdays		
Service Performance					
• Turnaround Time	Time from requisition to result availability	Time stamp laboratory requisitions at two points in process	Lab process times for Chemistry tests (routine and STAT), Hematology tests (routine and STAT), Bacteriology tests	Total turnaround time for Chemistry (routine and STAT), Hematology (routine and STAT), Bacteriology tests	
• Transcription Discrepancies	Number of transcription discrepancies	Medical record review	% of transcriptions with discrepancies		
• Lab Inquiries	Volume and type of telephone calls to laboratory	Monitoring and categorizing of calls	Volume of telephone calls by type (day shift, week days)	Volume of telephone calls (day and night shift, week days)	
• Patient Waiting Times	Waiting times at reception desk	Timed observations of patients waiting in reception area	Average patient waiting time		
Staff Perceptions of Laboratory Services	Perceptions of providers, nursing and laboratory staff	Self-administered questionnaire	Perception ratings using Likert scale	Perception ratings using Likert scale	Perception ratings using Likert scale
Patient Satisfaction with Laboratory Services	Patient satisfaction with laboratory services	Self-administered questionnaire	Satisfaction ratings using Likert scale	Satisfaction ratings using Likert scale	Satisfaction ratings using Likert scale

the data collection methodology and instruments in several instances, in view of the differences in procedures in the laboratory because of the TRILAB system.

(2) Samples sizes were chosen to provide as reliable as possible data, given the data available from the baseline evaluation.[2]

(3) Where the baseline data were unavailable or insufficient for evaluation purposes, an effort was made to collect such information via interviews and review of any available reports.

The post-implementation data collection plan was organized under the following data collection methodologies:

(1) Work sampling at NRMC Oakland: to collect data on distribution of laboratory personnel activities in the post-implementation for comparison with distribution of activities in the baseline. The major objective was to determine whether time spent in information handling activities had changed.

(2) Process time study at NRMC Oakland: to determine whether process times for return of test results had changed.

(3) Volume of telephone calls to the laboratory at NRMC Oakland: to determine whether changes had occurred in the volume of telephone inquiries to the laboratory as a result of the availability of results via the TRILAB system.

(4) Surveys of laboratory staff, providers and patients at NRMC Oakland and Wright Patterson: to determine whether satisfaction with clinical laboratory services had changed.

(5) Interviews and supplementary data collection: to obtain cost data, volume data, and other information.

Exhibit 2 summarizes the relationship between the evaluation elements and the data obtained in the post-implementation study.

EXHIBIT 2

TRILAB EVALUATION ELEMENTS AND DATA COLLECTION METHODS
POST-IMPLEMENTATION EVALUATION

Element	Data to be Obtained	Data Collection Methodology	Data Obtained NRMC Oakland	Data Obtained Wright Patterson	Data Obtained Eisenhower
Personnel Time Devoted to Information Handling	Time devoted to information activities, e.g. accessioning, logging, result preparation in:				
• Laboratory	Chemistry Hematology Bacteriology	Work sampling	Percent of time and man-hours per week by activity type	Perceptions	Estimates
• Provider Staff Time	Time saved due to TRILAB	Interviews	Estimates of time saved	Estimates	Estimates
Performance of Services					
• Turnaround Time	Time from requisition to result availability	Computer Inquiry	Laboratory process times for Chemistry tests (routine and STAT) Hematology tests (routine and STAT) Bacteriology tests		
• Transcription discrepancies	Number of transcription discrepancies	Interviews with laboratory supervisory staff	Estimates of changes in errors	Perceptions	Estimates
• Laboratory Inquiries	Volume and type of telephone calls to laboratory	Monitoring and categorizing of calls	Volume of telephone calls by type (day shift, weekdays)		
Staff Perceptions of Laboratory Services	Perceptions of providers, nursing and laboratory staff	Self-administered questionnaire	Perception ratings using Likert scale	Perception ratings using Likert scale	
Staff and Patient Satisfaction with Laboratory Services	Staff and patient satisfaction with laboratory services	Self-administered questionnaire	Satisfaction rating using Likert scale	Satisfaction rating using Likert scale	

Arthur D. Little, Inc.

III. EVALUATION RESULTS

This chapter summarizes the evaluation data collected during the baseline and post-implementation evaluations. Further details on evaluation findings are presented in the remaining volumes of this report. This chapter is organized according to the system goals and evaluation measures: (a) personnel time devoted to information handling (obtained only at NRMC Oakland); (b) performance of service measures (also obtained only at NRMC Oakland); (c) attitudes and perceptions about services (collected via survey questionnaires at NRMC Oakland and Wright Patterson); and (d) interview information (collected at all three sites).

A. PERSONNEL TIME DEVOTED TO INFORMATION HANDLING

One goal of the TRILAB system was to reduce time spent by laboratory staff in clinical or information-handling activities. In both the baseline and post-implementation studies at NRMC Oakland, time spent by laboratory personnel in information handling activities was measured by an extensive work sampling program conducted in the three major laboratory sections: *Chemistry*, *Hematology*, and Bacteriology.

1. Comparison of Baseline and Post-Implementation Results

Table 3 compares the time devoted to information handling activities in the baseline and post-implementation periods, in terms of both percent of time and estimated hours per week. The comparisons of percentage of time are considered more accurate than the comparisons of estimated hours per week, due to difficulties in interpretation of the estimates of weekly hours and staffing levels in the three sections during the baseline sampling period. (Baseline hours per week for Chemistry have been adjusted for comparison purposes to reflect the fact that the Nuclear Medicine section was not included in post-implementation sampling; Chemistry staff hours were reduced by 12.5 percent--the percent accounted for by Nuclear Medicine staff-- to make the results comparable.)

TABLE 3

COMPARISON OF BASELINE AND POST-IMPLEMENTATION INFORMATION HANDLING TIMES
TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Percent of Time			Hours per Week		
	Base-line	Post-Implementation	Difference	Base-line	Post-Implementation	Difference
Chemistry	37.3%	38.5%	1.2%	208.6[a]	161.7	-46.9
Hematology	18.1	15.4	-2.7[b]	68.0	73.9	5.9
Microbiology	22.6	21.0	-1.6[b]	103.5	84.0	-19.5
All	27.2[a]	24.6	-2.6[b]	380.1	319.6	-60.5

[a] Adjusted for Nuclear Medicine staff.

[b] Difference is statistically significant at 95% confidence level.

Overall, the percentage of time devoted to information handling activities was 2.6 percent lower in the post-implementation than in the baseline period; this difference was statistically significant.

Statistically significant (at a 95 percent confidence level) reductions in the percentage of time devoted to information handling activities were observed in Hematology and Microbiology sections (2.7 percent and 1.6 percent, respectively). An increase of 1.2 percent of time devoted to information handling activities was observed for Chemistry. This increase, however, was not statistically significant. The overall reduction in time devoted to information handling between the two study periods was about 60 hours per week. Part of this reduction, however, was due to the difference in staffing. At the staffing level during the post-implementation study, a reduction of 2.6 percent was equivalent to a reduction of 35.8 hours per week devoted to information handling activities, or slightly less than one FTE.

Table 4 compares the percentage of time devoted to several selected activities in the two study periods. Overall, time devoted to processing of test results increased by approximately 1.2 percent. As might be expected, time devoted to transcription and recording of test results was reduced by about 0.9 percent, equivalent to about 16 hours per week. Time devoted to compilation of workload statistics, which accounted for 1.5 percent, or 21 hours per week of time in the baseline period, was eliminated in the post-implementation period because the computer system assumed this function. Time devoted to quality control logging, calculation, and updating was reduced from 2.9 percent to 0.7 percent of total time, or by 31 hours per week.

Time spent away from the area was 25.2 percent in the post-implementation period compared with 32.7 percent in the baseline. It is not clear whether this was due to differences in sampling methodology, or whether the staff did spend more time in the laboratory sections, possibly as a result of reduction in available staff.

TABLE 4

COMPARISONS OF BASELINE AND POST-IMPLEMENTATION WORK SAMPLING RESULTS FOR SELECTED ACTIVITIES
TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Percent of Time Devoted to Activity								
	Chemistry		Hematology		Microbiology		Total		
	X Period	Y Period	X Period	Y Period	X Period	Y Period	X Period	Y Period	Difference
Process Test Results	19.8%	20.8%	30.1%	26.2%	29.1%	33.9%	25.6%	26.8%	1.2%
Transcribe and Record Test Results	4.3	4.8	3.1	0.2	3.1	0.1	4.0	3.1	-0.9
Compile Workload Statistics	2.9	0	1.9	0	0.4	0	1.5	0	-1.5
Quality Control Reporting	5.8	1.3	1.2	0.8	0.9	0.1	2.9	0.7	-2.2
Away From Area	25.9	17.2	41.2	32.0	33.8	25.4	32.7	25.2	-7.5
	Hours per Week Devoted to Activity								
Process Test Results	110.7[a]	87.4	113.7	125.8	133.4	135.6	357.8	348.8	9.0
Transcribe and Record Test Results	23.2	20.1	14.7	1.0	18.5	19.2	56.4	40.3	-16.1
Compile Workload Statistics	16.1[a]	0	3.3	0	1.6	0	21.0	0	-21.0
Quality Control Reporting	32.4[a]	5.5	4.4	3.8	4.0	0.4	40.8	9.7	-31.1
Away From Area	145.0[a]	72.2	155.9	153.6	155.1	101.6	456.0	327.4	-128.6

[a]Adjusted for Nuclear Medicine staff.

2. Conclusions

It was concluded that time devoted to information handling activities in the post-implementation period was approximately 2.6 percent lower than in the baseline. Based on current staffing, this was equivalent to a net reduction of 34 hours per week (day shift, Monday to Friday) devoted to information handling activities in the Chemistry, Hematology and Microbiology sections. As expected, there were reductions in time devoted to transcription and recording of test results, compilation of workload statistics, and for quality control reporting.

B. PERFORMANCE OF SERVICES

Another goal of the TRILAB system was to make information available to providers with increased efficiency. Data on two types of performance measures were collected at NRMC Oakland during the baseline and post-implementation periods:

- turnaround time for laboratory requisitions; and
- volume of telephone calls inquiring about test results.

1. Turnaround Times

a. Comparison of Baseline and Post-Implementation Laboratory Process Times

Table 5 compares process times observed in the two study periods. In the case of the STAT/urgent tests, the post-implementation averages presented are for the "CRT process time" (time results available via the CRT), as being most comparable to the process time measured in the baseline period (time when results were telephoned back to the requesting units). In the case of routine tests, the final results available via CRT are presented, as being most comparable to process times measured in the baseline period (completed results slips available for pickup).

The results suggest that process times were reduced in the post-implementation period compared to the baseline period for Hematology STAT/urgent tests (by 0.4 hours) and for Hematology routine tests (by 2.6 hours); these differences were statistically significant at the 95 percent confidence level. The process times for STAT/urgent and routine Chemistry tests increased (by 0.23 hours and 8.3 hours,

TABLE 5

COMPARISON OF BASELINE AND POST-IMPLEMENTATION AVERAGE PROCESS TIMES
TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Mean Turnaround Time (hours)			
STAT/Urgent	Baseline	Post-Implementation	Difference	F Test
Chemistry	1.27[a]	1.50[b]	0.23	2.6*
Hematology	1.25[a]	.85[b]	-0.40*	1.07
Routine				
Chemistry	16.1[c]	24.4[d]	8.3	2.8*
Hematology	4.7[c]	2.1[d]	-2.6*	12.3*
Microbiology	39.1[c]	59.6[d]	20.5*	3.5*

[a]Time from receipt of specimen by laboratory to telephoning results.
[b]Time from accessioning to availability of first results via terminal.
[c]Time from receipt of specimen to availability of results at distribution box.
[d]Time from accessioning to availability of final results via terminal.
*Statistically significant difference at 95% confidence level.

respectively); these differences, however, were not statistically significant. Average process times for Microbiology tests increased by about 20 hours; this difference was statistically significant.

The differences observed must be interpreted with caution for the following reasons:

- In the case of routine tests, the process times are not entirely comparable because in the baseline period the process time represents the time when the requisition slip was available for pickup, where the post-implementation process time represents the time that the result was in fact available to the requester (via terminal look-up). The time between availability of the completed requisition slip and pickup or availability of the result to the requester was not measured in the baseline study at NRMC Oakland. At DDEAMC,* however, total turnaround time was measured in addition to "process time;" the difference varied between 17 hours and 20 hours, on average. Thus routine results were available to the provider (via terminal inquiry) considerably sooner in the post-implementation period for routine Chemistry and Hematology tests, and probably in about the same time for Microbiology tests.
- During the post-implementation period, the tests to be sampled in each test type category were chosen by using an appropriate "skip" interval between tests, in order to obtain a random sample representative of turnaround times. It is not clear how the sample for the baseline period data collection was chosen; as indicated in the baseline report, much of the data was unusable due to lack of identification of data sheets, obvious errors (e.g., receipt dates being later than dates of results report) and errors in the calculation of process times,

*A mini baseline evaluation was conducted to evaluate TRILAB at Eisenhower AMC. Complete results are summarized in the baseline report, Volume III [2].

resulting in some questionable data. In fact, there is evidence that the distributions (spreads) of test result process times are not the same in the two periods, as measured by the statistical F Test. As indicated in Table 6, the distribution of test results in the two study periods are significantly different for each test category, except for Hematology STAT/urgent tests.

- Operating conditions in the laboratory were not the same in the two study periods. The Hematology Laboratory had obtained a new Coulter S+ instrument, which had a higher throughput rate than the previous instrument (the Coulter was the major instrument utilized in the Hematology section). Staffing in the Chemistry section, as mentioned earlier, was somewhat reduced from that of the baseline period. Also, staff were preparing for the Joint Accreditation visit, which may have resulted in fewer staff being available for production of tests.
- The apparent increase in Microbiology test times is difficult to explain, except for the possibility that the small baseline sample (16 observations) may not be representative of the tests carried out in the Microbiology section (specific tests and requesting locations were not provided in the baseline data); as mentioned above, the distributions of process times were significantly different. Since test times in Microbiology are longer and vary so much, depending on type of specimen and results (positive or negative), differences in the type of tests sampled in the baseline and post-implementation periods could result in considerably different test times, which masked any differences in reporting times.

b. Conclusions

Given the above qualifications, the following conclusions may be drawn:

(1) For STAT/urgent tests, process times--times between receipt of requisition and transmission of test results to provider locations (via telephone in the baseline period and via terminal in the post-implementation period)--were either unchanged (Chemistry) or reduced (Hematology).

(2) For routine tests, results were available to provider locations (via terminal) sooner in the post-implementation period than in the baseline period for Chemistry and Hematology, and in about the same time period or sooner for Microbiology. Hard-copy daily reports were generally available to providers later than the completed results requisition slips were in the baseline period. Interim hard-copy reports (for the surgical floors) were available sooner in the post-implementation period for Hematology tests, and in approximately the same time for Chemistry and Microbiology tests.

2. Number of Telephone Calls

a. Comparison of Baseline and Post-Implementation Results

Table 6 provides a comparison of the number of calls per day received by the laboratory at NRMC during the two study periods. In the post-implementation period study, the laboratory received an average of 67.4 calls per day. The total number of calls received per day during the post-implementation period was, therefore, two-thirds that received during the baseline period. The distribution of calls by type was similar to that received during the baseline period, with the majority of calls (51 percent) requesting information from the laboratory with regard to test results. The number of calls received was lower in each category of call request, except for calls to technicians, which doubled from 9 calls per day during the baseline period to about 18 calls per day during the post-implementation period. The reason for the increase in this category is not known.

Based on the 170,150 patient tests reported performed during October 1982, the average daily test load was 5,489 tests per day for the 31-day period. Assuming the number of telephone calls to the

TABLE 6

COMPARISON OF BASELINE AND POST-IMPLEMENTATION PERIOD TELEPHONE CALL RESULTS
TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Number per Eight-Hour Day		Ratio of Baseline to Post-Implementation	
Type of Call	Baseline	Post-Implementation	Unnormalized	Normalized for Workload
For filed results	12.5	2.9	0.23	0.20
Information from laboratory	62.4	34.4	0.55	0.48
Supervisor	12.9	8.8	0.68	0.59
Technician	9.0	17.8	1.98	1.72
General Information	5.6	3.5	0.63	0.55
TOTAL	102.4	67.4	0.66	0.57

laboratory was similar on weekdays and weekends, this represented an average of one call for every 81.4 tests performed. This was a reduction of 43 percent from the average of 1 call for every 46.5 tests measured during the baseline period.

It should be noted that not all nursing stations or clinics had terminals and not all areas of the laboratory (viz., Nuclear Medicine, Pathology and Blood Bank) were on the system. If additional terminals are obtained, the volume of telephone calls could be expected to be further reduced.

c. Conclusions

The volume of telephone calls to the laboratory was considerably reduced by implementation of the TRILAB system. Normalized to study period workloads, the volume of telephone calls in the post-implementation period was almost half (57 percent) that in the base-line study period.

C. STAFF PERCEPTIONS OF LABORATORY SERVICES

Survey questionnaires were distributed to medical staff, nurses, administrative corpsmen and clerical staff, and laboratory staff during the baseline and post-implementation studies. The purpose of the questionnaires was to determine the degree of satisfaction of various providers and staff with regard to their perceptions of laboratory operations. The baseline survey at Oakland was designed and carried out by ANSER, while the surveys at Wright Patterson were designed and carried out by A. D. Little, Inc. The results for Wright Patterson are somewhat more complete.

Questions were included with regard to perceptions about such factors as:

- relations with laboratory personnel;
- legibility, quality, accuracy and format of laboratory reports;
- amount of time required to obtain test results;
- promptness and completeness of laboratory reports in patient records; and
- ease of and amount of time required to obtain information by telephone.

TABLE 7

BASELINE AND POST-IMPLEMENTATION SATISFACTION LEVELS OF USERS OF CLINICAL LABORATORY SERVICES REGARDING PERFORMANCE OF THE CLINICAL LABORATORY AT NRMC OAKLAND[a]

Aspect	Satisfaction With Service Aspect (weighted Mean)[b]					
	Baseline Physicians	Post-Implementation Physicians	Implementation Change Physicians	Post-Implementation Nurses/PA	Post-Implementation Administration	Post-Implementation All Users
Accuracy of Results	3.7	4.3	0.6	4.2	4.1	4.2
Legibility/Clarity	3.9	4.5	0.6	4.6	4.4	4.5
Completeness of Results	3.9	4.2	0.3	4.2	4.1	4.2
Length of Time Between Routine Tests and Results	3.2	3.6	0.4	3.5	3.3	3.5
Length of Time Between STAT Tests and Results	2.8	3.3	0.5	3.0	3.4	3.2
Overall Laboratory Performance	3.6	3.9	0.3	3.7	3.9	5.8

[a] Baseline, 182 respondents; Post-implementation, 231 respondents: 89 physicians, 83 nurse/p.a., 58 administrators, 1 other.

[b] Weighted mean response was obtained by assigning values of 1 through 5 to the categories very satisfied, somewhat satisfied, undecided, somewhat unsatisfied, and very unsatisfied, and dividing the sum by the number of responses.

TABLE 8

BASELINE AND POST-IMPLEMENTATION SATISFACTION LEVELS OF USERS OF CLINICAL LABORATORY SERVICES REGARDING PERFORMANCE OF THE CLINICAL LABORATORY AT WRIGHT PATTERSON MEDICAL CENTER AND REGIONAL HOSPITAL[a]

Aspect	Satisfaction With Service Aspect (weighted Mean)[b]					
	Baseline Physicians	Post-Implementation Physicians	Implementation Change Physicians	Post-Implementation Nurses/PA	Post-Implementation Administration	Post-Implementation All Users
Accuracy of Results	3.0	4.1	+1.1	4.3	4.2	4.2
Length of Time Between STAT ER Test and Results	2.8	3.4	+0.6	3.0	3.7	3.3
Length of Time Between Inpatient STAT Tests and Results	2.7	3.2	+0.5	3.2	3.7	3.3
Length of Time Between Inpatient Routine Tests and Results	2.8	3.7	+0.9	3.4	3.8	3.6
Length of Time Between Outpatient Routine Tests and Results	3.2	3.8	+0.6	3.1	3.7	3.5
Ability of Laboratory to Handle Special Tests	2.7	3.3	+0.6	3.2	3.6	3.3

[a] Baseline, 46 respondents; Post-implementation, 76 respondents: 30 physicians, 31 nurse/p.a., 12 administrators, 3 others.

[b] Weighted mean response was obtained by assigning values of 1 through 5 to the categories very satisfied, somewhat satisfied, undecided, somewhat unsatisfied, and very unsatisfied, and dividing the sum by the number of responses.

Respondents were asked to rate satisfaction with each factor. These ratings, assigned scale values of 5, 4, 3, 2, 1 (the conventional Likert scale) were:

5 highly satisfactory;

4 satisfactory;

3 neither satisfactory nor unsatisfactory;

2 unsatisfactory; or

1 highly unsatisfactory.

1. User Attitudes

a. Clinical Laboratory Performance

Tables 7 and 8 summarize the changes in mean satisfaction levels at NRMC Oakland and Wright Patterson regarding clinical laboratory services.

At Oakland, satisfaction levels of physicians, nurses and physicians' assistants, and other users increased in all categories, with one exception (satisfaction by "other [administrative] users" with regard to overall laboratory performance). Physicians showed the greatest increase in satisfaction levels with regard to turnaround times of both routine and STAT tests. Nurses and physicians' assistants showed the greatest increase in satisfaction with regard to accuracy of results, completeness of laboratory reports, and test turnaround times.

The survey results at Wright Patterson show that TRILAB have resulted in positive changes in physician attitudes towards laboratory services, as evidenced in Table 8. Satisfaction with all aspects of performance of laboratory services increased from the baseline to the post-implementation survey. Physician opinion in the baseline was largely divided, as indicated by weighted means of approximately 3.0. The post-implementation period survey results indicate that, for the most part, physicians were basically "satisfied" with laboratory services. The most marked change was in satisfaction with accuracy of laboratory results; respective weighted mean changes from the baseline to post-implementation were 3.0 to 4.1, or "undecided" to "somewhat satisfied." There was also a significant increase in satisfaction with routine results turnaround time, from 2.8 to 3.7.

The surveys at both NRMC Oakland and Wright Patterson thus show positive changes in user attitudes towards laboratory services.

b. Frequency of Problem Occurrences

Users at Oakland NRMC were asked to compare relative frequency of problem events under TRILAB operations with previous laboratory (manual) operations. Only those users who were at the facility before TRILAB was installed (in February 1982) were asked to answer this question. Two-thirds of the respondents to the post-implementation survey fell into this category.

The TRILAB system received relatively "high marks" for most problem categories (Table 9). The median response was that the following occurred "less frequently" with the TRILAB system:

- tests repeated due to delays (43.4 percent felt they occurred less frequently);
- tests repeated due to lost results (46.7 percent); and
- telephone calls to the laboratory (64.6 percent).

The median response to "tests repeated due to inaccurate results" was that this occurred with similar frequency (40.3 percent). Unnecessary duplication of report data also received a median response of "similar frequency with TRILAB."

Table 10 summarizes the responses received at Wright Patterson to the same questions. Again, the median response was that the following problems occurred "less frequently" with the TRILAB system:

- tests repeated due to delays (58.2% felt they occurred less frequently);
- tests repeated due to lost results (63.6%);
- telephone calls to the laboratory (65.5%); and
- unnecessary duplication or report data (54.7%).

"Tests repeated due to inaccurate results" were judged to occur with similar frequency (38.9%) or less frequently (44.4%).

Thus, the questionnaire surveys at both NRMC Oakland and at Wright Patterson indicated that users felt that problem occurrences were less frequent after implementation of TRILAB.

TABLE 9

COMPARISON OF TRILAB WITH MANUAL OPERATIONS
POST-IMPLEMENTATION PERIOD OF USERS
NRMC OAKLAND*

	Change in Frequency (Percent of Respondents)				
	More Frequently With TRILAB	Similar Frequency	Less Frequently	Never with TRILAB	No Opinion
Tests repeated due to delays	9.3%	23.1%	43.4%	1.6%	22.5%
Tests repeated due to lost results	6.0	24.7	46.7	2.7	19.8
Tests repeated due to inaccurate results	0.6	40.3	29.3	2.2	27.6
Telephone calls to Laboratory	6.1	14.4	64.6	2.2	12.7
Unnecessary duplication of report data	35.7	13.2	24.2	2.2	24.7

*Completed by users who were also at the hospital prior to installation of TRILAB.

TABLE 10

COMPARISON OF TRILAB WITH MANUAL OPERATIONS
POST-IMPLEMENTATION PERIOD OF USERS
WRIGHT PATTERSON MEDICAL CENTER*

	Change in Frequency (Percent of Respondents)				
	More Frequently With TRILAB	Similar Frequency	Less Frequently	Never with TRILAB	No Opinion
Tests repeated due to delays	3.6%	21.8%	58.2%	3.6%	12.7%
Tests repeated due to lost results	3.6	23.6	63.6	3.6	5.5
Tests repeated due to inaccurate results	-	38.9	44.4	3.7	13.0
Telephone calls to Laboratory	3.6	14.5	65.5	14.5	1.8
Unnecessary duplication of report data	9.4	17.0	54.7	9.4	9.4

*Completed by users who were also at the hospital prior to installation of TRILAB.

2. Attitudes of Clinical Laboratory Personnel

Separate baseline and post-implementation survey questionnaires were administered to the personnel on the laboratory staff of NRMC Oakland and Wright Patterson. Detailed results are presented in Volumes II and III of this report.

a. Relative Frequency of Problem Occurrences

When asked to compare operations under TRILAB with manual operations prior to installation of TRILAB (Table 11), respondents at NRMC Oakland (who had been with the laboratory prior to installation of TRILAB) indicated that the following occurred less frequently with TRILAB:

- telephone calls to providers (73 percent);
- time spent on manual record-keeping (47 percent); and
- duplication of information (41 percent).

The following were judged to occur with similar frequency under TRILAB:

- repeating tests due to inaccurate results (53 percent); and
- transcription discrepancies (43 percent).

Laboratory personnel at Wright Patterson were, overall, in agreement that frequency of common laboratory discrepancies either decreased or occurred with similar frequency in the post-implementation period (Table 12). The following were judged to occur less frequently:

- telephone calls to providers (82%); and
- repeating tests due to inaccurate results (36%).

The following were estimated as occurring with similar frequency:

- duplication of information;
- time spent on manual record keeping; and
- transcription discrepancies (55%).

Thus laboratory personnel at both NRMC Oakland and Wright Patterson indicated that frequency of events which interfered with flow of work, in particular telephone calls, had decreased.

TABLE 11

COMPARISON OF TRILAB WITH MANUAL OPERATIONS
POST-IMPLEMENTATION PERIOD OF LABORATORY PERSONNEL
NRMC OAKLAND

	Change in Frequency (Percent of Respondents)				
	More Frequently With TRILAB	Similar Frequency	Less Frequently	Never with TRILAB	No Opinion
Telephone calls to inpatient units/ outpatient clinics	6.7%	20.0%	73.3%	0%	0
Duplication of information	20.7	17.2	41.4	10.3	10.3
Necessity of repeating tests due to inaccurate results	3.3	53.3	30.0	13.3	10.0
Time spent on manual record keeping	20.0	33.3	46.7	0	0
Discrepancies in transcription	23.3	43.3	20.0	3.3	10.0

TABLE 12

COMPARISON OF TRILAB WITH MANUAL OPERATIONS
POST-IMPLEMENTATION PERIOD OF LABORATORY PERSONNEL
WRIGHT PATTERSON MEDICAL CENTER

	Change in Frequency (Percent of Respondents)				
	More Frequently With TRILAB	Similar Frequency	Less Frequently	Never with TRILAB	No Opinion
Telephone calls to inpatient units/ outpatient clinics	0 %	9.1%	81.8%	0 %	9.1%
Duplication of information	9.1	45.5	36.4	0	9.1
Necessity of repeating tests due to inaccurate results	9.1	18.2	36.4	18.2	18.2
Time spent on manual record keeping	0	81.8	18.2	0	0
Discrepancies in transcription	0	54.5	45.5	0	0

3. Patient Satisfaction

A sample of patients at NRMC Oakland and Wright Patterson were asked to complete a brief questionnaire regarding their satisfaction with laboratory services. The laboratory at NRMC Oakland received comparatively high ratings by patients in both study periods. The overall satisfaction rating remained generally unchanged (4.5), as did satisfaction with waiting times for specimen taking (4.2). There was a decrease in satisfaction rating of waiting time required to register (from 4.5 to 4.1). Patients were also asked to indicate whether they had to have tests repeated due to lost results or whether they experienced delays due to incomplete test request forms. Most patients indicated that they "never" or "rarely" experienced such problems. Two to three percent indicated that they occurred "often." About 22 percent of patients added comments to their questionnaire. The majority of these were laudatory, and referred to the "excellent service" received at the facility or that they had experienced no problems.

No patient data were available for analysis in the baseline period at Wright Patterson. In the post-implementation period, patients were on average "somewhat satisfied" with clinical laboratory services at Wright Patterson, including time waiting to be served in the laboratory. Delayed or repeated tests were considered to occur on average between "rarely" and "never."

D. RESULTS OF INTERVIEWS

During the study periods and implementation monitoring visits, interviews were held with a number of laboratory supervisors and with users, with regard to benefits achieved with the TRILAB system, and any problems encountered. The following summarizes the results of these interviews.

1. Laboratory Staff

a. Benefits Achieved in Laboratory

- **Telephone Calls**

  Laboratory staff at all three sites felt that a very significant decrease had occurred in telephone calls to the laboratory, which had interrupted work flow and taken up staff time.

At Oakland, supervisors estimated that telephone calls to the laboratory had been reduced by about 50 percent, because of availability of results and test status to providers via terminal inquiry. (The study of telephone call volume indicated that telephone call volume decreased by 43 percent.) Staff at Eisenhower estimated that volume of telephone calls was reduced by 40-50 percent (in Chemistry and Hematology), equivalent to savings of about 6-1/2 hours per day of staff time.

- Workload Reporting. Supervisors at the three sites felt that TRILAB accomplished management and workload reporting tasks more efficiently than in the baseline. Supervisors at Oakland estimated that in the three major sections (Chemistry, Hematology, and Microbiology), approximately 8.5 hours per week in total were saved by having the TRILAB system produce the monthly workload reports; these reports were previously prepared manually. (This compares with the reduction of 21 hours estimated from the work sampling study data.) At Eisenhower, supervisors estimated a savings of ten hours per week (in Chemistry and Hematology).
- Quality Control Reports. Supervisors indicated that the quality control reports of the system (Levey-Jennings charts) were a significant benefit. Supervisors at Oakland estimated that 11 hours per week were saved in preparing the quality control reports, which were produced by the TRILAB computer system. Staff at Eisenhower estimated staff savings of three hours per week.
- Patient Exception Reports. It was estimated at Oakland that approximately ten hours per week were saved in review of patient exception reports, due to the highlighting of abnormal results by the computer system.
- Logging of Specimens and Preparation of Work Sheets. Staff at Eisenhower estimated that reduction of time spent in these activities averaged 14 staff hours per day.

- Duplicate Tests. It was anticipated that the number of duplicate or repeated tests may be reduced with the TRILAB system.(3) Laboratory staff suggested that this could occur for two reasons: (1) providers could easily check on the status of tests, and would be less inclined to repeat an order if they saw a test was pending or in process; (2) abnormal results and unusual "delta checks" (abrupt changes from the previous day's results) showed up on the screen as they were entered, so that extra attention was given to such results. This may have resulted in fewer result report errors.

  Supervisors at all three sites felt that duplication of tests was reduced, but that the effect was likely small. Supervisors at Oakland estimated that there might be a reduction of approximately one percent in total tests because of the improvement. This would approximate a reduction of about 450 tests per week based on the current workload. Nursing staff estimated that 40 or 50 duplicated tests per week might have been avoided. To be conservative, it was estimated that 100 duplicate tests per week may be avoided, representing about 0.2 percent reduction in total tests.

In addition to the above (quantifiable) estimates of benefits, laboratory staff cited the following benefits:

- Reduction in Transcription Errors. Because abnormal results were highlighted on the CRT screens, and received extra scrutiny by technicians and reviewers, there was potential for reduction of transcription errors. It was felt, however, that such reduction in errors was likely small.
- Normal Ranges Data. The system provided the capability to provide normal ranges data with each test (which is a CAP accreditation requirement). This may not have been universally provided previously, at least for the majority of tests for which the users were expected to know what the normal ranges were.

- Search Capability. The availability of the computerized data base of test results and associated demographic data provides the potential capability of performing a variety of analyses with regard to utilization, epidemiologic analysis, etc. This capability had not been utilized at the time of the post-implementation study.
- Management Reporting. At the time of the post-implementation study at Oakland, the workload reporting system was being enhanced to provide a more detailed analysis of workload by section, shift and day of week, and analysis of workload per assigned (FTE) staffing. This would enable laboratory management to improve the allocation of staffing resources in response to workload, and thereby improve the overall efficiency and effectiveness of laboratory services.

b. Problems

Laboratorians articulated a few problems that they have had with TRILAB, one of them being the response time of the system. Some personnel felt that terminal response time, for example when inputting corrections, was long, and others felt that response time was long at peak periods of the day.

Another set of problems mentioned was the software associated with the Microbiology ("BACTI") module, which did not have verification or "batch entry" features.

2. Benefits to Providers

The following is based on interviews with providers (nursing staff and physicians) at the three sites.

- Reduced Staff Time. Nursing staff at all three sites estimated that there was considerable reduction in staff time associated with telephoning the laboratory to receive test results and to inquire about late or missing results, in filing time due to having cumulative reports available, and in chart review.

Staff at NRMC Oakland estimated that savings amounted to 4.2 hours per inpatient unit or clinic (which had terminals), for a total savings in the hospital of 75.6 staff hours per day. Thus time savings was thereby made available for other activities. At Wright Patterson, nursing staff estimated, on average, savings of 3.5 hours per unit, equivalent to 49 hours savings in staff time in the hospital. At Eisenhower, nursing staff estimated an average savings of 3.7 hours per unit, or 26 hours per day in the hospital.

- Duplicate Tests. Nursing staff at the three sites estimated that there was less duplication of tests, perhaps resulting from the fact that results appeared on the terminal as they became available, and there was less chance they would be lost. It was felt, however, that such reduction was small.
- Decreased Turnaround Time. Turnaround time for test results, especially for routine tests, had been reduced, contributing to the reduction in telephone calls. Providers indicated that this may have resulted in improved patient care.
- Improved Morale. As a result of being able to look up test status on the terminal, and the reduction in telephone calls to the laboratory, nurses felt that relationships between nursing and laboratory staff had improved considerably.
- Retrieval of Information. Users interviewed relied heavily on TRILAB's information storage and retrieval capabilities. All comments in this regard were highly positive. This capability was reported to provide a great deal of information to users, possibly improving patient care.
- Identification of Abnormals. Because abnormal results were identified (by an asterisk), leading to faster and easier identification of patient problems, providers felt that patient care has been improved.

To summarize, both the questionnaire survey (Section C) and the interviews indicated that health care providers were generally pleased with the TRILAB system, citing as advantages reduced telephone calls, decreased test turnaround times, improvements in relationships with laboratory personnel, an improvement in quality of care due to easier and faster access to test results, identification of abnormal values, and cumulative report formats.

A further indirect measure of approval of the system was the expressed desire of staff in those inpatient units and outpatient clinics that did not have terminals (and had to share a terminal in another location) for a terminal in their own location.

One problem that was expressed fairly uniformly was the need for additional training for users, particularly administrative staff (corpsmen). It was felt that additional hands-on training would be particularly useful, in addition to the formal (lecture) type of training.

IV. COMPARISON OF RESULTS WITH PROJECT OBJECTIVES

On July 15, 1977, the TRIMIS Medical Review Group (MRG) developed seven project objectives for the Tri-Service Laboratory System[3]. In this section, the results obtained in the evaluation are related to these original objectives.

1. To Make Information Available to Physicians with Increased Efficiency and Accuracy

Providers reported that turnaround time for test results had decreased with the TRILAB system; this was confirmed in the analysis of turnaround times. The turnaround study showed that for routine tests, results were available to provider locations in less time for Chemistry and Hematology tests, and in about the same time period or sooner for Microbiology. For STAT/urgent tests, process times were either unchanged (Chemistry) or reduced.

Telephone calls to the laboratory were also reported to occur with less frequency under the operation of the TRILAB system than with the previous system, as well as tests repeated due to delays or to lost results. These indicators suggest that information was being made available to physicians with increased efficiency. Data were not available to make a comparison of accuracy of results; laboratory personnel believed, however, that accuracy of results may have been improved because of highlighting of unusual values by the system, facilitating review of such results. Most providers felt, however, that repeating of tests due to inaccurate results occurred with similar frequency with the TRILAB system as before.

Providers, especially those on inpatient services, were very satisfied with the ability of retrieving patient laboratory results via terminal inquiry, and with the cumulative results reports. In some cases the cumulative reports were used to supplement the manual "flow sheets," and in others had replaced them. Nursing personnel at all three sites estimated that, on average, approximately four staff hours per day had been saved at each inpatient unit or outpatient clinic which had a terminal, through reductions in time on the telephone, filing time, and chart review.

2. To Present the Data in a Convenient and Meaningful Manner with Sufficient Variety in Report Formats to Meet the Needs of All Users

Providers reported that they were very satisfied with the report formats provided by the TRILAB system. Both physicians and nursing staff indicated significant increase in their satisfaction with legibility of laboratory reports between the two study periods.

3. To Be Able to Handle Increased Demands for Laboratory Testing Without Significant Increases in Staff

The evaluation results indicate that less time of laboratory staff was being devoted to clerical activities, such as workload reporting, quality control reporting, and transcription and recording of test results, on telephone calls, and in number of staff required at the reception area. At Oakland, the percent of time devoted to processing of test results increased by a (modest) 1.2 percent. These results suggest that the TRILAB system will improve the ability of laboratory personnel to handle increased demands without significant increases in staff.

4. To Provide Accountability of Laboratory Requests and To Monitor Generation of Test Results to Include Providing Notices of Abnormal Values or Improper Quality Control Results as Soon as They are Available

The system provides immediate highlighting of abnormal values and unusual changes from previous results, facilitating review by laboratory personnel and pathologists. This objective is therefore considered to have been met.

5. To Gather as a Result of Normal Procedures, Workload and Managerial Data, and to Present This as Required in Order to Assist in Decision-Making in the Laboratory

The system gathered and presented workload data (thereby reducing the time devoted to this activity). The workload reports were being modified to enhance their capability to provide workload and managerial data, which should lead to improved capability of allocating laboratory resources in response to required workload.

6. To Reduce the Clerical Work Required of Qualified Technicians in the Laboratory

The work sampling results at Oakland indicate that, overall, time devoted to information handling activities was about 6 percent less in the post-implementation period compared with the baseline period; this difference was about 2.6 percent of total laboratory technician staff time. Laboratory personnel at all three sites indicated that identification of incomplete and pending tests and results was improved by the TRILAB system and that time spent on manual record-keeping occurred less frequently with the TRILAB system. They reported that "efficiency of laboratory operations" and "ease of information storage and retrieval" were either "very important" or "somewhat important" improvements due to TRILAB.

The major change in non-personnel operating costs in the laboratory was likely due to a reduction in duplicated tests, and the associated reagent costs. Providers and laboratory staff at Oakland estimated that the reduction might have been approximately 100 tests per week.

7. To Improve Result Accuracy by Eliminating Transcription, Calculation, and Specimen Identification Error

No data were available to measure this effect. Providers and laboratory staff at the three sites, however, believed that such errors have been somewhat reduced, resulting in fewer duplicate tests required.

It is concluded that the original project goals have by and large been met, albeit modestly for the objectives of enabling the laboratory to handle increased demands for testing and for reducing the clerical work required by laboratory technicians.

REFERENCES

(1) Analytic Services, Inc., The Evaluation Plan (Pre-Period X) for the Tri-Service Laboratory Initial Capability Information System, Contract MDA 903-78-C-0085, Report to TRIMIS Program Office, Bethesda, MD, June 30, 1980.

(2) Arthur D. Little, Inc., Baseline Evaluation of the Tri-Service Laboratory System, Contract MDA 903-81-C-0209, Report to the TRIMIS Program Office, Bethesda, MD, August 1982.

(3) TRIMIS Program Office, Initial Project Objectives and Evaluation Criteria, September 1, 1977.